Financial Informatics – I
Introduction

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https://www.cs.tcd.ie/Khurshid.Ahmad/Teaching.html

Financial Informatics:
A preamble

Financial informatics is sometimes defined as the structure and behavior of systems for storing, processing and communicating financial data.

Flood, Mark D. (2006). ***Embracing Change: Financial Informatics and Risk Analytics***
http://papers.ssrn.com/sol3/papers.cfm?abstract_id=924618

Financial Informatics:
A preamble

Financial informatics is an approach to deal with uncertainties in a comprehensive manner. These uncertainties can be:

(a) in the financial markets due to the statistical volatility of the prices of securities and returns,
(b) due to political risks such as changes in regulation or market structure that alter strategic priorities,
(c) caused by technological risks such as new product innovation, and model risks such as new mathematical techniques or software implementations.

Flood, Mark D. (2006). ***Embracing Change: Financial Informatics and Risk Analytics***
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Financial Informatics:
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'Forces' affecting risk management	Definition
Financial Innovation	**The process of experimentation with and creation of new financial products**
Model risk	**The possibility that a given analytical model or its implementation is incorrect or inappropriate for the task at hand.**
Strategy evolution	**The possibility that the strategic goals and priorities that justify a particular analytical toolkit may themselves be changing, in response to financial innovation,** legal and regulatory changes, macroeconomic developments, research innovations, or changes in a firm's balance-sheet or portfolio composition, among other things.

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Financial Informatics:
A preamble

Problems in finance and business are amongst the hardest problems to be solved on computer systems:

Financial and business systems are comprised and continuously react to and interact with a range of agents – humans and machines – in fairly noisy environments;

Financial and business systems evolve in time behaving cyclically, regressively, showing growth, actual or perceived, and showing decay.

Financial and business systems can be guided and show signs of self-organisation and learning.

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Financial Informatics:
A preamble

Problems in finance and business are amongst the hardest problems to be solved on computer systems:

- **The data sources are interdependent: behaviour of enterprises affect the markets, people and private and public sector organizations.**

- **But the behaviour of markets and people and organizations affect the enterprises → butterflies fluttering in Beijing cause rain (!) in Dublin;**

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Financial Informatics:
A preamble

The prices and traded volumes of equities and commodities change frequently when the markets are open. A market facilitates trading and has mechanism for stabilising prices. However, sometimes the prices, and more so the traded volumes, exhibit *flightiness*.

Financial Informatics:
A preamble

Financial and commodity asset prices change over time. The range and the speed of the variation in prices 'are statements that contain enough detail to specify the probability distributions of future prices. More ambitiously, it has been suggested that the stakeholders in the markets can use the behaviour of the prices (and traded volumes) to estimate 'future prices and the risk to which the [stakeholders] […] are exposed' (Taylor 2005:1). More precisely, it is the return on investment that usually is the key and typically it is the *continuously compounded return* that is used rather than the prices.

Taylor, Stephen J. (2005). *Asset Price Dynamics, Volatility and Prediction*. Princeton & Oxford: Princeton University Press.

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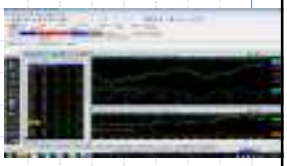
Financial Informatics:
A preamble

Volatility: Prices are expected to react to trading stimuli (demand and supply) and there is always some background 'noise' – small changes in prices that cannot be easily explained and the economists and econometricians use metaphors like *Brownian motion* in liquids/gases, or attempt to use the *random walk* model to explain this noise. However, sometimes the noise overwhelms the signal – the usual stimuli are neglected rather the stakeholders start to believe in rumors, follow fashion, and prices spiral (upwards/downwards) out of control. Market volatility studies use estimates of the variance in returns to compute *realised (or historical)* volatility, stochastic volatility, and implied volatility.



Taylor, Stephen J. (2005). *Asset Price Dynamics, Volatility and Prediction*. Princeton & Oxford: Princeton University Press.

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Financial Informatics:
A preamble

Problems in finance and business are amongst the hardest problems to be solved on computer systems:

• The analysis of this data has to be carried out in real time and the data bubbles through *data nurseries* (markets and technical data) and has to be excavated from *data tombs* (fundamental data).

• The analysis has to include methods developed for (non-linear) dynamical systems, for self-organising systems, for approximate reasoning, for adapting to newer types of data related to innovative financial instruments.

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Financial Informatics:
A preamble

Problems in finance and business are amongst the hardest problems to be solved on computer systems:

• In addition to the fundamental and technical/market data, we now have the nebulously defined *behavioural data.* This data relates to behaviour of individual stakeholders (traders, regulators, commentators, and increasingly other computers), governmental policies, changes in fashion, unexpected events, market related announcements and so on. All this is regarded as *news* in the economics/finance literature.

• The quantification of this affect data is a key ontological and computational problem – involve information extraction, data mining, fuzzy logic, knowledge representation and many aspects of intelligent systems.

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Financial Informatics:
A preamble

Computers systems can

- **Receive and send data across the Universe,**
- **help us in Internet banking,**
- **launch, fly and land flying machines ranging from a simple glider to the Space Shuttle.**

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Financial Informatics:
A preamble

- Computer systems cannot satisfactorily manage information flowing across a hospital.
- The introduction of computer systems for public administration has invariably generated chaos.
- Computer systems have been found responsible for disasters like flood damage, fire control and so on.

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Financial Informatics:
A preamble

So why can't the computers do what we want the computers to do?

1. Problems in engineering software – specification, design, and testing;
2. Algorithms, the basis of computer programs, cannot deal with partial information, with uncertainty;
3. Much of human information processing relies significantly on approximate reasoning;

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Financial Informatics:
A preamble

So why can't the computers do what we want the computers to do?

The solution for some is *soft computing* – where methods and techniques developed in branches of computing that deal with partial information, uncertainty and imprecision

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Financial Informatics:
A preamble

"Soft computing differs from conventional (hard) computing in that, unlike hard computing, it is tolerant of imprecision, uncertainty, partial truth, and approximation. In effect, the role model for soft computing is the human mind. The guiding principle of soft computing is: Exploit the tolerance for imprecision, uncertainty, partial truth, and approximation to achieve tractability, robustness and low solution cost."

The above quotation is from http://www.soft-computing.de/def.html

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Financial Informatics:
A preamble

Soft computing is used as an umbrella term for sub-disciplines of computing, including fuzzy logic and fuzzy control, neural networks based computing and machine learning, and genetic algorithms, together with chaos theory in mathematics.

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Financial Informatics:
A preamble

Soft computing is for the near future – next 5-10 years, and knowledge of the inclusive branches will help to work in almost every enterprise where computers are expected in helping with design, control and execution of complex processes.

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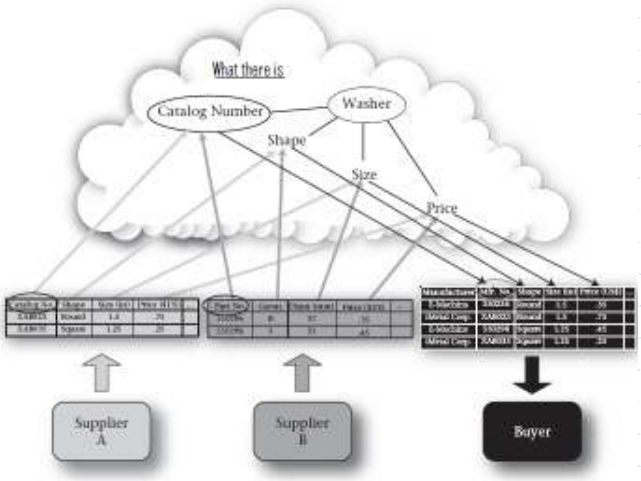
Financial Informatics: A preamble – An example

Economic actors involved in buying and selling *washers*; each actor has his or her view as to what the attributes of a washer are; all this knowledge of *what there is* is in or her head.



Obrst, Leo., Howard Liu, and Robert Wray (2003). 'Ontologies for Corporate Web Applications'. *AI Magazine* Volume 24 (No 3), pp 49-62 (http://www.aaai.org/ojs/index.php/aimagazine/article/viewFile/1718/1616)

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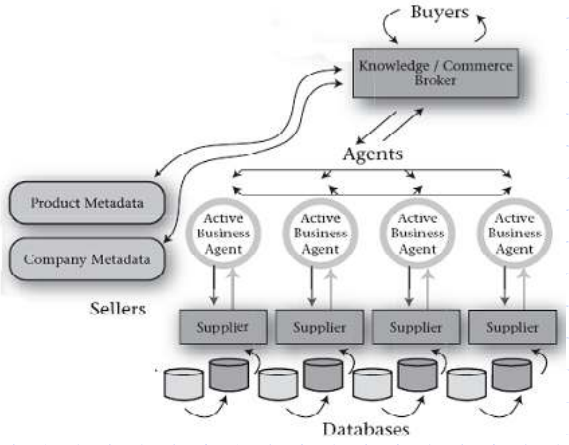
Financial Informatics: A preamble – Information and Data Processing

Economic actors involved in buying and selling *washers*; each actor has his or her view as to what the attributes of a washer are; the actors share a common *vocabulary*; all this *knowledge* of *what there is* is in or her head.



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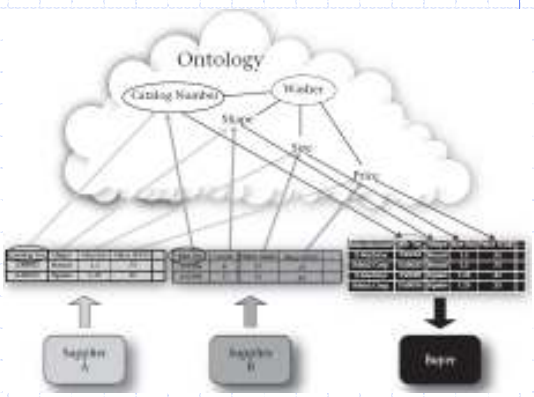
Financial Informatics: A preamble

Economic actors involved in buying and selling *washers*: the actors share a vocabulary or *terminology*; they build *taxonomies* according to what the actors believe there exists – *ontology* or ontological commitment; and then they have *facts* and *rules* (of thumb) in which their *knowledge* is perhaps encoded.



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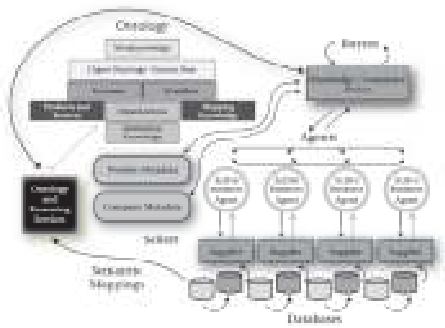
Financial Informatics: A preamble

Financial informatics will enable economic actors to deploy software systems that will eventually be able to compute and manage risks much like their human counterparts. Here ontology systems will play a key role. These systems will be able to inter-operate with other systems and people.



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Financial Informatics:
A preamble

Problems in finance and business are amongst the hardest problems to be solved on computer systems:

• Why are there now over 8,000 hedge funds? The reasons of course include economic and political developments, but it is also important that setting up a hedge fund is much easier in 2006 than it was 20 years ago. The real-time interconnection of trade-capture and other systems makes it possible to standardise, automate and risk-manage administrative and prime-brokerage services, which can thus be supplied on an industrial (rather than 'cottage industry') scale and relatively cheaply.' (Hardie and Mackenzie 2007:36-37)

Hardie, Iain and Mackenzie, Donald. (2007) Assembling an Economic Actor: The Agencement of a Hedge Fund," *Sociological Review* Vol 55 (No. 1), pp 57-80.

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Financial Informatics:
A preamble

Problems in finance and business are amongst the hardest problems to be solved on computer systems:

'[A]n economic actor is not an individual human being, nor even a human being 'embedded in institutions, conventions, personal relationships or groups'. For Callon, an actor is 'made up of human bodies but also of prostheses, tools, equipment, technical devices, algorithms, etc'. – in other words is made up of an *agencement* [...] *Agencer* is to arrange or to fit together: in one sense, *un agencement* is thus an assemblage, arrangement, configuration or lay-out.' (Hardie and Mackenzie 2007:3)

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Financial Informatics:
A preamble

Problems in finance and business are amongst the hardest problems to be solved on computer systems:

•Economic actors can be viewed as nodes in a socio-technical network or *agencements* – a network comprising human beings, computer systems, including algorithms, heuristics, communication devices.

Hardie, Iain and Mackenzie, Donald. (2007) Assembling an Economic Actor: The Agencement of a Hedge Fund," *Sociological Review* Vol 55 (No. 1), pp 57-80.

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Financial Informatics:
A preamble

Problems in finance and business are amongst the hardest problems to be solved on computer systems:

- **The *agencement of economic actors* in an interconnected world is formally endless. It appears that is not possible for a single actor to acquire and/or process the information available within the *agencement*.**

Hardie, Iain and Mackenzie, Donald. (2007) Assembling an Economic Actor: The Agencement of a Hedge Fund," *Sociological Review* Vol 55 (No. 1), pp 57-80.

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Financial Informatics:
A preamble

Problems in finance and business are amongst the hardest problems to be solved on computer systems:

- **The complexity of financial modelling typically requires deployment of multiple financial analytics packages, drawing data from multiple source systems. Business domain experts are typically needed to understand the data requirements of these packages. Financial product innovation and research advances imply that data requirements are chronically unstable.**

Flood, Mark D. (2006). ***Embracing Change: Financial Informatics and Risk Analytics***
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Financial Informatics:
A preamble

Problems in finance and business are amongst the hardest problems to be solved on computer systems:

• *Society for Worldwide Interbank Financial Telecommunication:* **connect and exchange financial information securely and reliably; to automate and standardise financial transactions, to reduce operational risk and to eliminating inefficiencies in the operations of banks and finance houses**

• International Securities Association for Institutional Trade Communication **to facilitate straight-through processing (STP) among custodian banks, investment manager, and broker dealers;**

•**FIX** The Financial Information eXchange ("FIX") Protocol is a series of messaging specifications for the electronic communication of trade-related messages.

• **OMGEO** automating trade lifecycle events, including allocation, confirmation / affirmation, settlement notification, enrichment, operational analytics and counterparty risk management between trade counterparties

Flood, Mark D. (2006). ***Embracing Change: Financial Informatics and Risk Analytics***
http://papers.ssrn.com/sol3/papers.cfm?abstract_id=924618

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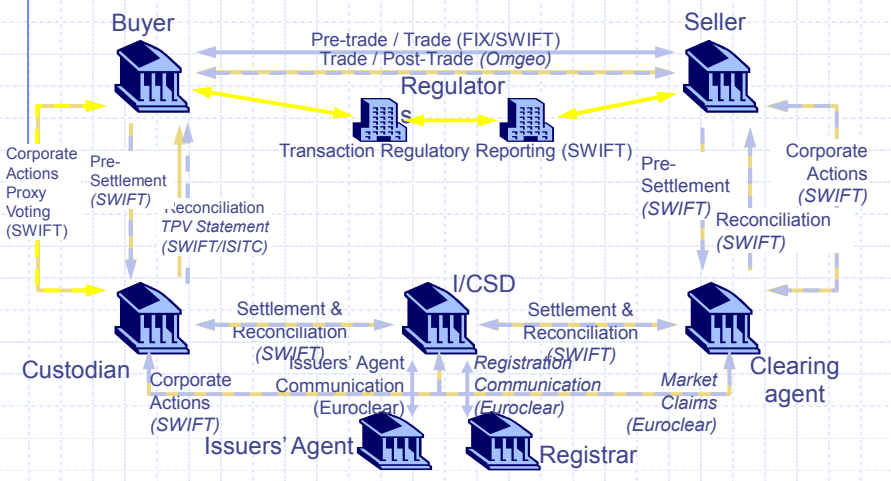
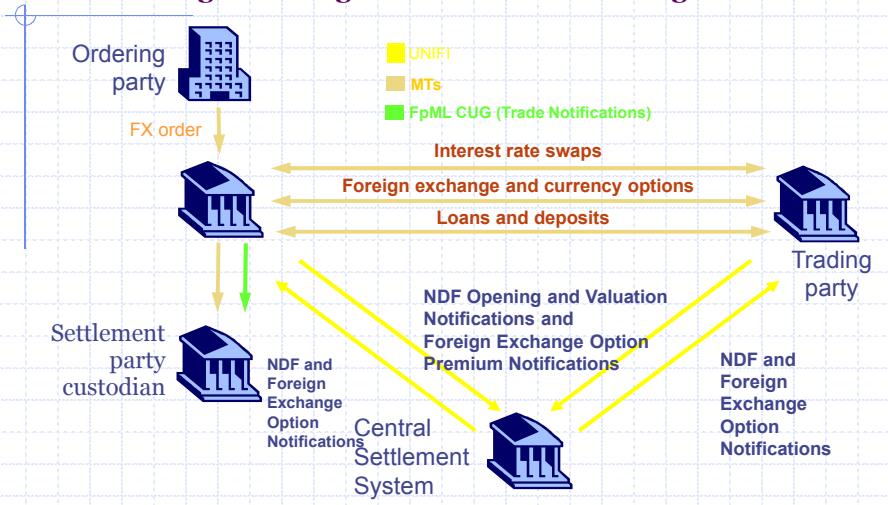
Financial Informatics:
A preamble: *agencement* or economic actors involved in equities and fixed income according to ISO



SOURCE: http://www.iso20022.org/documents/general/Scripted_UNIFI_ppt_short_version_v13.ppt

Financial Informatics:

A preamble: *agencement* or economic actors involved in foreign exchange transactions according to ISO



SOURCE: http://www.iso20022.org/documents/general/Scripted_UNIFI_ppt_short_version_v13.ppt

Financial Informatics:
A preamble

Problems in finance and business are amongst the hardest problems to be solved on computer systems:

- **A robust financial information system require the incorporation of the knowledge of as many of the economic actors as possible within the system → federated knowledge bases dealing with a specific application, the knowledge to learn and adapt, the knowledge to deal with uncertainty**

- **The system should have some of the beliefs and values of the actors → the knowledge of the ontological commitments of the actors.**

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Financial Informatics:
Course Outline

Problems in finance and business are amongst the hardest problems to be solved on computer systems:

• **This course deals with two branches of computing that aim explicitly to deal with such problems: soft computing (4/5) and grid computing (1/5).**

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Financial Informatics:
Course Outline

Problems in finance and business are amongst the hardest problems to be solved on computer systems:

• **SOFT COMPUTING: Complementing the conventional/algorithmic systems in finance, we have a collection of computational methods and systems that are used in the modeling and analysis of complex systems – the soft computing methodology and related soft computing systems. These include knowledge-based expert systems, fuzzy logic systems and neural computing systems. We will cover these three systems in the next three days.**

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Financial Informatics:
Course Outline

Problems in finance and business are amongst the hardest problems to be solved on computer systems:

• **GRID COMPUTING: The competitiveness of the financial industry depends critically upon the availability of highly-optimized IT infrastructure. One solution to the problems is the use of loosely-coupled computers acting in concert, for performing large scale tasks including economic forecasting and back-office data processing. Grid computing, a form of distributed computing, is increasingly being used by financial organizations.**

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Financial Informatics:
Semantic Web and Ontology

Despite having all the wonderful modern computing software and hardware systems, a financial operative (analysts, managers, …) still have to rely on fusing information generated by different software systems – frequently *scraping screens* to make a decision. And, the operatives still have to manually fuse data coming in different modalities – text, numbers, images.

But this is the predicament of almost all computer users using distributed systems, like the Internet for the general public and enterprise-wide systems used. The solution it seems is the so-called SEMANTIC WEB

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Financial Informatics:
Semantic Web and Ontology

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The Semantic Web is a web of data. We all use data some of which is on the Web and some in our personal possession – digitally or otherwise.

Paraphrased from W3 Semantic Web Consortium http://www.w3.org/2001/sw/

Financial Informatics:
Semantic Web and Ontology

The Semantic Web is a web of data. We all use data some of which is on the Web and some in our personal possession – digitally or otherwise.

You have your bank statements on the web. You have your photo albums on your PC as you have your work/leisure appointments in a calendar on the PC. But can you see your photos in a calendar to see what you were doing when you or somebody took them? Can you see your statement lines in your calendar?

Paraphrased from W3 Semantic Web Consortium http://www.w3.org/2001/sw/

Financial Informatics:
Semantic Web and Ontology

The Semantic Web is about two things.

It is about common formats for integration and combination of data drawn from diverse sources, where on the original Web mainly concentrated on the interchange of documents.

It is also about language for recording how the data relates to real world objects. That allows a person, or a machine, to start off in one database, and then move through an unending set of databases which are connected not by wires but by being about the same thing.

Paraphrased from W3 Semantic Web Consortium http://www.w3.org/2001/sw/

W3C Semantic Web

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W3C Semantic Web

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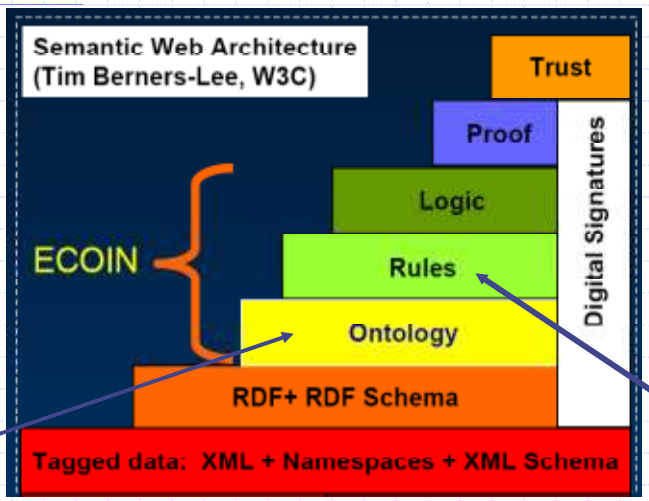
Financial Informatics:

Semantic Web and Ontology



http://www.mit.edu/~bgrosof/paps/talk-ecoin-icis02.pdf

But just before I go on with rest of my talk--

Theories and Things

Ontology is a branch of philosophy, and some philosophers believe that to understand what ***is*** in every area of reality one should look into the theories of sciences (Quine 1981).

Ontology, if understood in its religious sense as 'what there is' (a deity usually), then ontology or rather the ontological commitment as to what there is fixed for all times – otherwise we will not have a diety!!

So do ontological commitments change over time within a community and across communities at fixed point in time

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Financial Informatics:
Special languages and linguistic writing

The growth in the size and complexity of the vocabulary of a specialist language, and the concomitant use of limited grammatical structure, usually accompanies a growing body of knowledge (see, for example, Gerr 1943 and Halliday and Martin 1995).

Sentences in specialist writing are usually of declarative and imperative type.

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Financial Informatics:
Semantic Web and Ontology

Level of 'knowledge'	Elaboration
INVENTORY/ GLOSSARY	A collection of glosses; a list with explanations of abstruse, antiquated, dialectal, or technical terms; a partial dictionary.
TERMINOLOGY	Etymologically, The doctrine or scientific study of terms; in use almost always, The system of terms belonging to any science or subject; technical terms collectively; nomenclature.
TAXONOMY	Classification, esp. in relation to its general laws or principles; that department of science, or of a particular science or subject, which consists in or relates to classification; *esp.* the systematic classification of living organisms.
ONTOLOGY	The science or study of being; that branch of metaphysics concerned with the nature or essence of being or existence.

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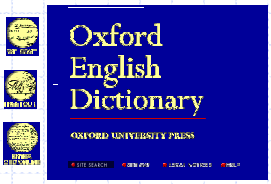
Financial Informatics:
Being Intelligent Beings

Knowledge



Intelligence ⟷ Cognition

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Financial Informatics:
Being Intelligent Beings

Knowledge about*, *knowledge by description: knowledge of a person, thing, or perception gained through information or facts about it rather than by direct experience.

Language; Images
Symbols; Planning;
Learning, Thinking;
Creativity

An impersonation of **intelligence**; an intelligent or rational being; esp. applied to one that is or may be incorporeal; a spirit

⟷

COGNITION: The action or faculty of knowing taken in its widest sense, including sensation, perception, conception, etc., as distinguished from feeling and volition.

with apologies to Plato

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Financial Informatics:
Being Intelligent Beings

Knowledge of a person, thing, or other entity (e.g. sense-datum, universal) by direct experience of it, as opposed to knowing facts about it. So ***knowledge of, by, acquaintance***

Language; Images
Symbols; Planning;
Learning, Thinking;
Creativity

INTELLIGENCE: Knowledge as to events, communicated by or obtained from another; information, news, tidings.

COGNITION: A product of such an action: a sensation, perception, notion, or higher intuition

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Financial Informatics:
Being Intelligent Beings

- Intelligent beings perceive, reason and act.
- Intelligent beings are creative, learn from their mistakes.
- Intelligent beings can learn from their environment.
- Intelligent beings can learn with the help of tutors.
- Intelligent beings can work on their own/form groups.
- Intelligent beings have a value system, an exchange system.

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Soft Computing – a definition

"Soft computing is […] a partnership. The Principal partners at this juncture are *fuzzy logic* (FL), *neurocomputing* (NC) and *probabilistic reasoning* (PR), with the latter subsuming *genetic algorithms* (GA), *chaotic systems, belief networks* and parts of *learning theory*…"

Lotfi A Zadeh 1997:xvi

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Soft Computing – a definition

"Fuzzy logic is a methodology for computing with words;

Neurocomputing systems can identify, learn and adapt;

Probabilistic reasoning strategies help to propagate belief;

Genetic algorithms are algorithms for systematized random search and optimization"

Lofti A Zadeh (1997). "Foreword" to Jang, Sun and Mizutani, pp.xv-xvii

(Jang, Jyh-Shing R., Sun, Chuen-Tsai, and Mizutani, Eiji (1997). *Neuro Fuzzy and Soft Computing*. Upper Slade River (NJ): Prentice Hall.)

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The Rise of Soft Computing

Artificial intelligence, traditional AI that is, focuses on logic, particularly predicate logic, and on physical symbol systems, together with an assortment of symbol manipulation techniques.

Expert systems, natural language processing systems, reported in the literature, typically deal with some aspect of crisp/non-deviant logic together with symbol manipulation techniques.

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The Rise of Soft Computing

- Intelligent control systems, systems actually used in the real world, benefited from so-called *linguistic* variables, e.g., hot, warm, OK, cool, cold/high, medium, low and *fuzzy* rules (if temp. high then liquid hot or warm) obtained from *human control operator*.
- Relationships between diseases and symptoms (in medical diagnosis), between sent and received messages (on a Comms. Line) are more naturally described *probabilistically* rather than *categorically*.

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The Rise of Soft Computing

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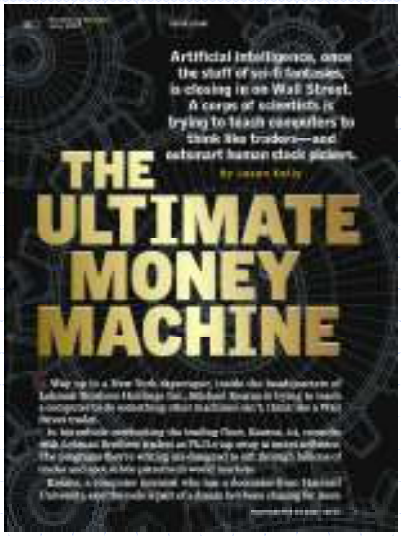
The Promise of Artificial Intelligence



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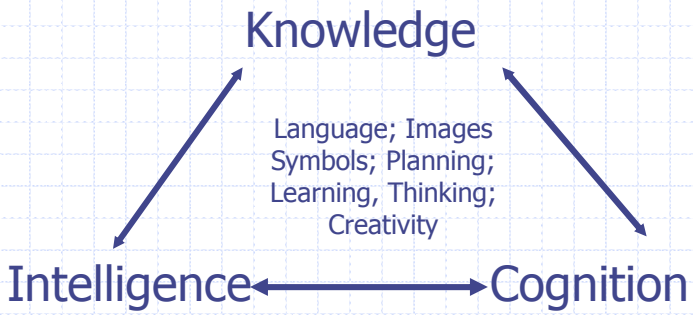
Financial Informatics:
Being Intelligent Beings

Artificially intelligent computing systems attempt to solve problems based on an interpretation of work in psychology, neurobiology, linguistics, mathematics and philosophy.



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Financial Informatics:
Being Intelligent Beings

Characteristics of an A.I. program

Problem types: A typical A.I. program will deal with problems whose solution require a certain amount of intelligence, and a general solution to the problems is not known.

Methods of solution: A typical A.I. program will employ methods of solution which will take advantage of whatever is known about human intelligence.

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Financial Informatics:
Knowledge-based Systems

A *knowledge-based system* can be programmed to reason over a set of facts, propositions, rules and rules of thumb and, system may comes to the same conclusion as a human being.

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Computing Intelligently?

Artificially intelligent programs

Problem-solving Expert Systems

Natural Language Processing Systems

Computer Vision Systems

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Computing Intelligently – with 'rules of thumb'?

Prevent the hi-jacking of airliners

Prevent hi-jackers from boarding the airliners

Heuristic technique

- Put passengers and luggage through a metal detector.
- Search only those who set off the detector
- Search those passengers that match a predetermined hi-jacker profile

Algorithmic route

- Strip search every person with access to the airlines (inc. passengers, flight crews & mechanics)
- Search all luggage

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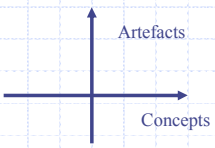
Knowledge Engineering Spiral

Acquire Knowledge:
Interview Experts; Collect Documents; Build Termbases
Identify Rules;
Establish Ontological Committments



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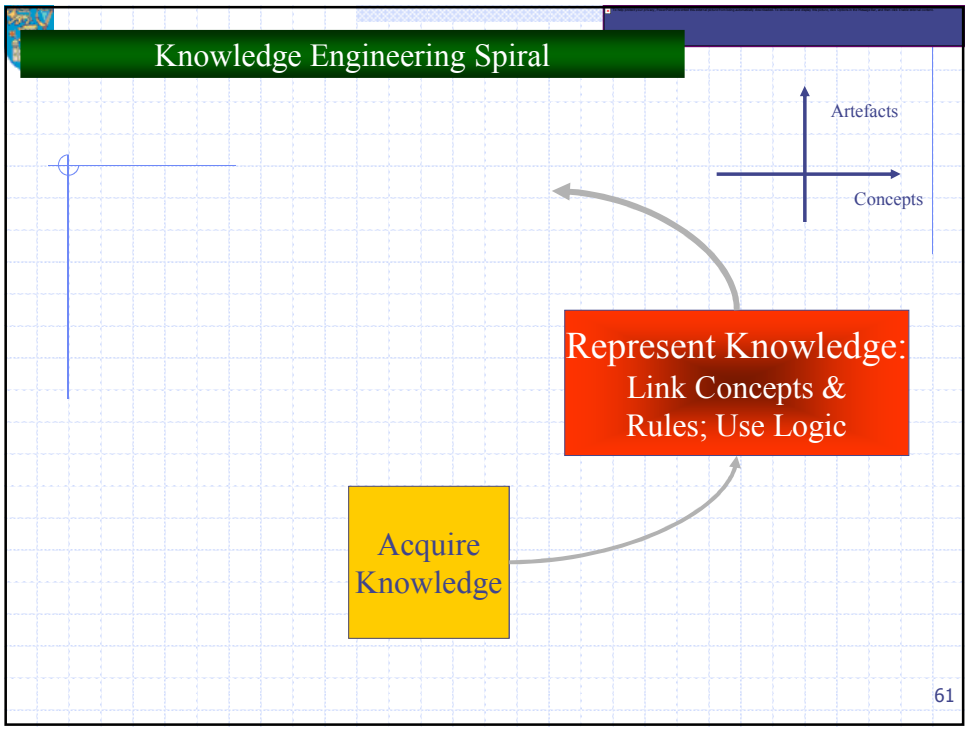
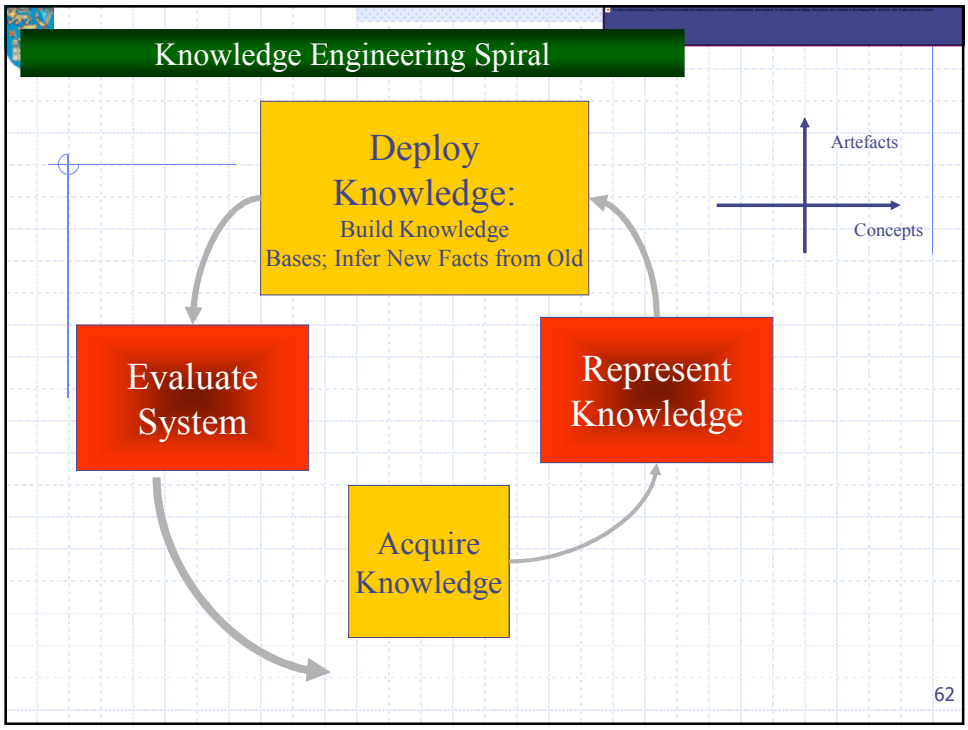
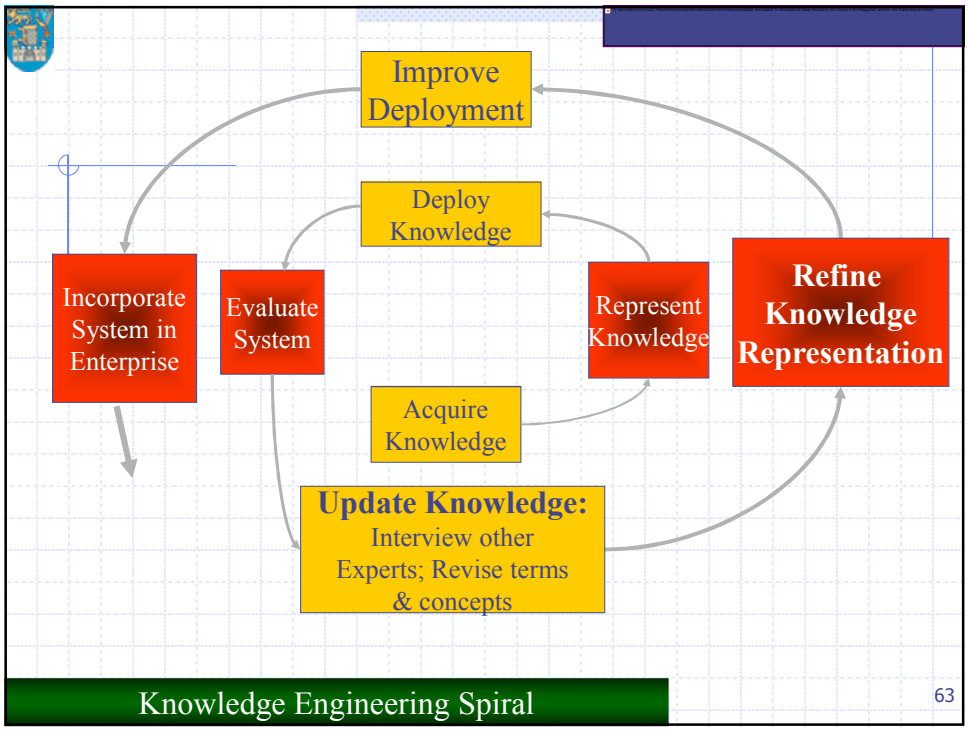

Knowledge Engineering Spiral
Artefacts
Concepts
Represent Knowledge:
Link Concepts &
Rules; Use Logic
Acquire
Knowledge
61


Knowledge Engineering Spiral
Deploy
Knowledge:
Build Knowledge
Bases; Infer New Facts from Old
Artefacts
Concepts
Evaluate
System
Represent
Knowledge
Acquire
Knowledge
62



Computing Intelligently – with 'rules of thumb'?

Knowledge-Based Systems	Inputs	Actions	Goals	Environment
Medical diagnosis systems	Symptoms, findings, patient's answers	Questions, tests, treatments	Healthy patient, minimise costs	Patient, hospital *NHS Direct*
Satellite image analysis systems	Pixels of varying intensity, colour	Print a categorisation of scene	Correct categorisation	Images from orbiting satellite *Defense app.*
Part-picking robots	Pixels of varying intensity	Pick up parts and sort into bins	Place parts in correct bins	Conveyor belt with parts *Ford US*
Refinery controller system	Temperature, pressure readings	Open, close valves; adjust temperature	Maximise purity, yield, safety	Refinery *ICI Runcorn*

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Learning to Compute Intelligently?

Artificial Neural Networks (*ANN*) are computational systems, either hardware or software, which mimic animate neural systems comprising biological (*real*) neurons. An ANN is architecturally similar to a biological system in that the ANN also uses a number of simple, interconnected artificial neurons.

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Learning to Compute Intelligently?

Fuzzy logic is being developed as a discipline to meet two objectives:

1. **As a professional subject dedicated to the building of systems of high utility – for example fuzzy prediction and control**
2. **As a theoretical subject – fuzzy logic is "symbolic logic with a comparative notion of truth developed fully in the spirit of classical logic [..] It is a branch of many-valued logic based on the paradigm of inference under vagueness.**

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